




International Seminar on Early Warning and Business Cycle Indicators

**14 to 16 December 2009
Scheveningen, The Netherlands**

OECD system of leading indicators, 2008

**Gyorgy Gyomai and Emmanuelle Guidetti
OECD**



OECD SYSTEM OF COMPOSITE LEADING INDICATORS

November 2008

TABLE OF CONTENTS

This methodology guideline has been prepared by Gyorgy Gyomai and Emmanuelle Guidetti. We would like to thank Mr. N. Ahmad, Mr. D. Brackfield, Mr. R. Nilsson and Ms. E. Tosetto for their precious help.

OECD'S COMPOSITE LEADING INDICATORS (CLI).....	3
PURPOSE.....	3
PRE-SELECTION.....	4
Reference series.....	4
Selection of the component series	5
FILTERING.....	6
Periodicity.....	6
Seasonal adjustment.....	6
Outlier detection.....	6
Cycle identification (de-trending, smoothing and turning points detection)	6
Normalisation	7
EVALUATION.....	7
Length and consistency of the lead.....	8
Cyclical conformity between selected indicators and reference series.....	8
Missing or extra cycles.....	8
Performance.....	8
AGGREGATION.....	8
Weighting	8
Lag-shifting and inversion.....	9
Aggregation.....	9
PRESENTATION	9
The amplitude adjusted CLI vs. the de-trended reference series.....	9
The trend restored CLI vs. the original reference series	10
The 12-month rate of change of the CLI vs. similar reference series	11
ANNEX A – CYCLES EXTRACTION (DE-TRENDING AND SMOOTHING).....	13
Phase Average Trend (PAT) Method.....	14
Hodrick-Prescott (HP) Filter	15
Christiano-Fidgerald (CF) filter.....	16
ANNEX B – TURNING POINTS DETECTION.....	17
BIBLIOGRAPHY.....	18

OECD'S COMPOSITE LEADING INDICATORS (CLI)

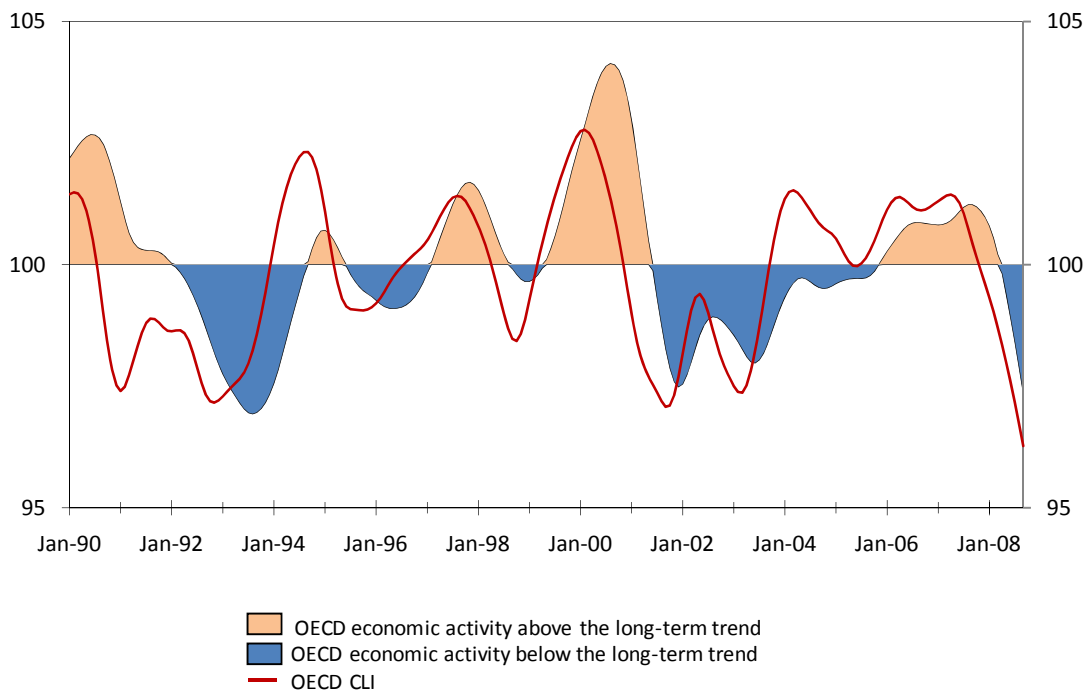
PURPOSE

The **OECD system of composite leading indicators** was developed in the 1970's to give early signals of turning points of economic activity. This information is of prime importance for economists, businesses and policy makers to enable timely analysis of the current and short-term economic situation.

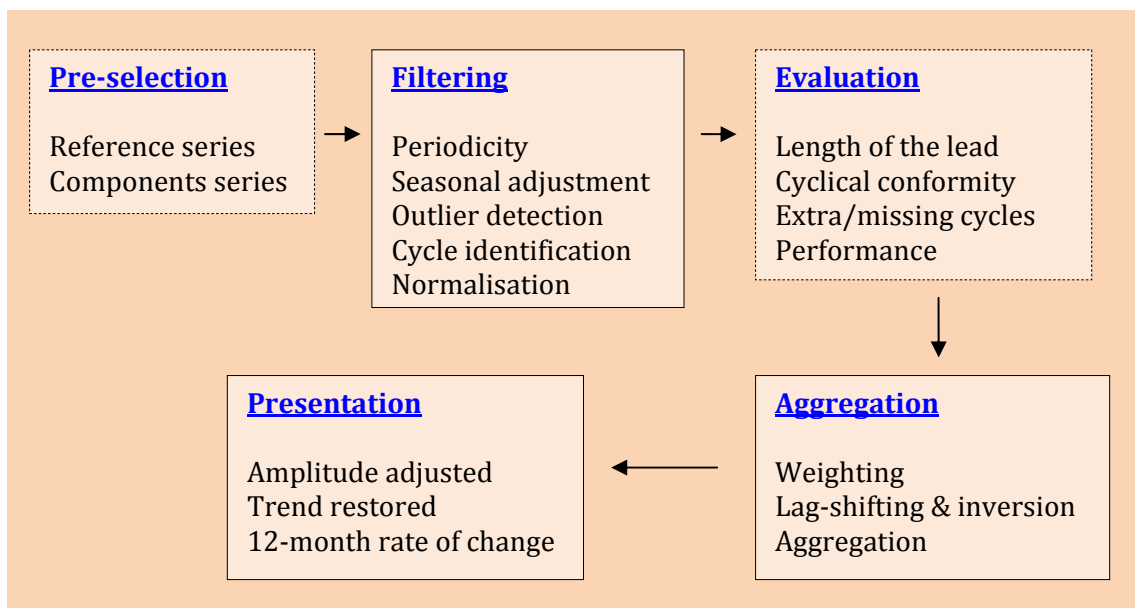
OECD CLIs are constructed to predict cycles in a reference series chosen as a proxy for economic activity. Fluctuations in economic activity are measured as the variation in economic output relative to its long term potential. The difference between potential and observed output is often referred to as the output gap, and the fluctuation in the output gap as the business cycle. The output gap is not however observable directly, indeed, this is estimated as part of the overall CLI production process.

The chart below presents the CLI and the estimated business cycle for the OECD area. The two series show strong co-movements, with the turning points of the CLI consistently preceding those of the business cycle.

OECD area Composite Leading Indicator (CLI) and economic activity
(long-term trend = 100)



The figure below presents the steps of the OECD CLI selection and production process:



The pre-selection and evaluation steps are only processed during the selection of the component/reference series and related factors (filtering procedures and aggregation parameters) used in producing estimates of the CLI. Once these various factors and series have been selected the CLI specification is fixed until they are next reviewed, which occurs periodically to ensure the CLI retains its relevance. Component series, for example, may no longer be appropriate for CLI purposes, either for economic or statistical reasons (e.g. their timeliness may lengthen, and, indeed, in some cases their production may be suspended altogether). In this context it is important to note that changes to these factors and series are also used to recalculate historical estimates of the CLI.

The following sections provide a more detailed description of the various steps highlighted above.

PRE-SELECTION

Reference series

OECD CLIs are constructed from economic time series that have similar cyclical fluctuations to those of the business cycle but, and importantly, which precede those of the business cycle. Typically, movements in GDP are used as a proxy for the business cycle but, because they are available on a more timely and monthly basis, the OECD CLI system uses, instead, indices of industrial production (IIP) as proxy reference series. Moreover despite their tendency towards higher volatility, historical turning points of IIPs coincide well with those of GDP for most OECD countries.

Selection of the component series

The selection process considers a wide range of short-term indicators¹. Component series are selected for inclusion in the CLI system on the basis of the following criteria:

- **Economic relevance**

Economic significance: the observation of a leading relationship between a potential components series and the reference series is not in itself sufficient – an economic justification for the relationship is also needed before the potential component series can be accepted as an indicator.

Breadth of coverage: series with a broad coverage of economic activity are preferred to narrowly-defined series.

- **Practical considerations**

Frequency: monthly series are preferred to quarterly.

Revision: series that are not subject to significant revisions are preferred.

Timeliness: data should be timely, being made available very soon after the period to which they refer.

Length: long time series with no breaks are preferred.

Potential leading indicators are classified to one of four types of economic rationale, shown below, that can be used to assess their suitability as leading indicators.

Early stage: indicators measuring early stages of production, such as new orders, order books, construction approvals, etc.

Rapidly responsive: indicators responding rapidly to changes in economic activity such as average hours worked, profits and stocks.

Expectation-sensitive: indicators measuring, or sensitive to, expectations, such as stock prices, raw material prices and expectations based on business survey data concerning production or the general economic situation/climate e.g. confidence indicators.

Prime movers: indicators relating to monetary policy and foreign economic developments such as money supply, terms of trade, etc

Notwithstanding the fact that there may be a one-to-many relationship between a potential component indicator and the four rationale above, the CLI system attempts to balance the composition of a given CLI and the cyclical events that can impact on it, by including indicators from each of the 4 categories.

¹The MEI database, which provides the main source for selected indicators, covers macroeconomic indicators for the following major subject areas: (1) GDP and its components and industrial production, (2) selected commodity output variables (crude steel, crude petroleum etc.), (3) business and consumer tendency survey series, (4) selected manufacturing variables (deliveries, stocks, new orders etc.), (5) Construction, (6) domestic trade, (7) labour market series, (8) consumer and producer prices, (9) money aggregates, (10) interest rates, (11) financial variables, (12) exchange rates, (13) international trade and (14) balance of payments data:

http://www.oecd.org/document/54/0,3343,en_2649_33715_15569334_1_1_1_1,00.html

FILTERING

Once the leading components have been selected the second (and first step of production) begins. This step attempts to remove factors, such as seasonal patterns, outliers, trends etc that may obscure the underlying cyclical patterns in the component series, using what are referred to as a sequence of filters. Each of these factors, and the approaches used to identify and remove them, are described below.

Periodicity

OECD composite leading indicators are published monthly and are largely composed using monthly leading component series. Some of the component series are, however, only available on a quarterly basis, and these need to be converted to a monthly frequency. This conversion from quarterly to monthly is achieved via linearly interpolating quarterly series and aligning them with the most appropriate month of the quarter, depending on the nature/construction of the quarterly series. For most series this is the central month of the quarter but where quarterly dates refers to the end of the period, the final month of the quarter is aligned, and for quarterly series based on surveys conducted in a given month of the quarter, the month itself is aligned.

Seasonal adjustment

Many of the component series used in the CLI system are seasonally adjusted by the source provider, usually statistical offices. This is not the case however for all component series. In these cases, seasonal adjustments are made using either the X12 or TRAMO/SEATS methods².

Outlier detection

Outliers are observations in component series that lie outside the normal range of expected observations. Often their cause is identifiable: for example, a strike, a change in regulation, etc.

The OECD system of leading indicators utilises the TRAMO module of the TRAMO/SEATS seasonal adjustment procedure³ to identify outliers in each series. After the location and nature of the outliers identified, the outliers are replaced by an estimated value, the process for which varies depending on whether the outliers reflect: (i) additive outliers (caused by a temporary shock); (ii) transitory changes (also caused by temporary shocks but where observations return to normal after several periods); and (iii) level shifts (consequence of a permanent shock). In addition TRAMO can also provide estimates in cases of missing values.

Cycle identification (de-trending, smoothing and turning points detection)

The next step in the filtering process is to identify the underlying cyclical pattern of the component indicator. This requires the removal of two factors: long term trends and high frequency noise. The process of removing these factors can be performed in a single step (referred to as band-pass filtering), or separated into distinct steps for trend removal and smoothing.

² <http://circa.europa.eu/irc/dsis/eurosam/info/data/demetra.htm>

³ For further information see “Brief description of the TRAMO-SEATS methodology”, in Modelling Seasonality and Periodicity, Proceedings of the 3rd International Symposium on Frontiers of Time Series Modelling, the Institute of Statistical Mathematics, Tokyo, 2002.

De-trending and Smoothing

Up until November 2008 the OECD CLI system determined the long-term trend using the Phase Average Trend method (PAT) developed by the US National Bureau of Economic Research. Series smoothing was conducted using the Month for Cyclical Dominance (MCD) method. Following a study⁴ undertaken in 2008 that compared the revision properties of PAT, the Hodrick-Prescott filter and the Christiano-Fidgerald filter, the OECD has decided to replace the combined PAT/MCD approach with the Hodrick-Prescott filter. This change not only improves the stability of the cyclical estimates, but also makes the CLI production process more transparent and delivers greater operational stability.

For more information on the de-trending methods mentioned above see [annex A](#)

Before the HP filter is applied the TRAMO module is applied to component series to determine whether they should be modelled as additive or multiplicative series, and to provide short horizon stabilizing forecasts. Multiplicative series are subject to a log-transformation, after which they can be processed in the same way as additive series. Once this has been determined the HP-filter is run as a band-pass filter with parameters set, such that the frequency cut-off occurs at frequencies higher than 12-months and lower than 120 months.

Turning Point Detection

The algorithm currently used to detect turning-points is a simplified version of the Bry-Boschan algorithm. It selects local minima and maxima in the cyclical part of the series, but, at the same time, enforces minimum phase length and minimum cycle length conditions, and ensures the alternation of troughs and peaks. For further details on turning point estimation see [Annex B](#).

The identification of turning-points is also an important criterion used in determining whether component indicators have suitable leading properties, (used mainly in the evaluation stage).

Normalisation

Naturally, even after the above steps have been conducted, the different component series used in the construction of a single composite indicator will be expressed in different units or scales. As such, the various component series that are used in the construction of a CLI are first normalised. This normalisation process is achieved by subtracting from 'filtered' observations the mean of the series, and dividing this by the mean absolute deviation of the series, and, finally, by adding 100 to each observation.

EVALUATION

This step is only part of the selection process of the CLI and does not apply to the regular monthly CLI calculation and update routine.

The pre-selected candidate component series are evaluated for their cyclical performance using a set of statistical methods. The OECD system of composite leading indicators examines the cyclical behaviour of each candidate component series in

⁴ <http://www.oecd.org/dataoecd/32/13/41520591.pdf>

relation to the cyclical turning points of the reference series, i.e. peak-and-trough analysis. This assessment is summarised below:

Length and consistency of the lead

Lead times are measured in months, reflecting the time that passes between turning points in the component and reference series. Of course lead times vary from turning point to turning-point but the aim is to construct leading indicators whose lead times are on average between 6 to 9 months and that have relatively small variances. To evaluate the length of leads, both mean and median leads are used, because the mean lead on its own can be strongly affected by outliers. The consistency of leads is measured by the standard deviation from the mean lead.

Cyclical conformity between selected indicators and reference series

If the cyclical profiles are highly correlated, the indicator will provide a signal, not only to approaching turning points, but also to developments over the whole cycle. The cross correlation function between the reference series and the candidate components (or the composite leading indicator itself) provides invaluable information on cyclical conformity. The location of the peak of the cross correlation function is a good alternative indicator of average lead time. Whereas the correlation value at the peak provides a measure of how well the cyclical profiles of the indicators match, the size of correlations cannot be the only indicators used for component selection.

As a cross-check the average lead of the cyclical indicator, measured by the lag at which the closest correlation occurs, should not be too different from the median lag if the composite leading indicator is to provide reliable information about approaching turning points and the evolution of the reference series.

Missing or extra cycles

Clearly selected component indicators should not flag extra cycles or, moreover, miss any cycles compared to the reference series. Indeed, if too many extra cycles are flagged, the risk that the CLI gives false signals becomes significant. Equally, if the CLI failed to predict several cycles in the past it is unlikely to be reliable in anticipating changes in the future.

Performance

After selection the component indicators are combined and aggregated into various composite indicators. The best performing composite indicator is selected based on the same assessment criteria described above.

AGGREGATION

Weighting

Component indicators used in constructing any composite leading indicator have equal-weights. But for zone aggregates the CLIs themselves are weighted reflecting country weights: for more information see the OECD CLI zone aggregation methodology (<http://www.oecd.org/dataoecd/56/25/38873830.pdf>)

It is important to note however that the normalisation procedure, described above, introduces an implicit weighting of component series, with the series being weighted by the inverse of their mean absolute deviation.

Lag-shifting and inversion

Having a reference series means having a reference chronology to classify the timing of series as either:

- leading (movements precede those of the reference series),
- coincident (movements coincide with those of the reference series), or
- lagging (movements follow those of the reference series)

In this respect, the following classification system is used in the CLI:

Type of behaviour at turning points	Median lead/lag
Coincident	between +/- 2 months
Leading: shorter/medium longer	Between 2 months to 8 months over 8 months
Lagging	-2 months or less

It is important to note that some component series may have counter-cyclical (inverse) behaviour compared to the reference series. But such characteristics can be as useful in the CLI construction as pro-cyclical series.

Lag-shifting is a new feature incorporated into the process. It reflects the lagging of the different selected component series for a given CLI such that, in practice, the lead-times of the component series align with each other, thus maximising the intensity of turning points in the CLI.

Aggregation

Aggregation of component indicators is clearly done with a view to improving the predictive capacity of the overall composite indicator. But some complications can arise in aggregation reflecting the availability of data for component series, both historical and current. As a rule therefore, for any given period, a CLI is only calculated if data for 60% or more of the component series are available in that period.

The aggregation is done by averaging the growth rates of each component indicator. Then, the average growth rates are chained to form the final indicator. The advantage of this procedure is that the CLI is less sensitive to missing or late arriving component data.

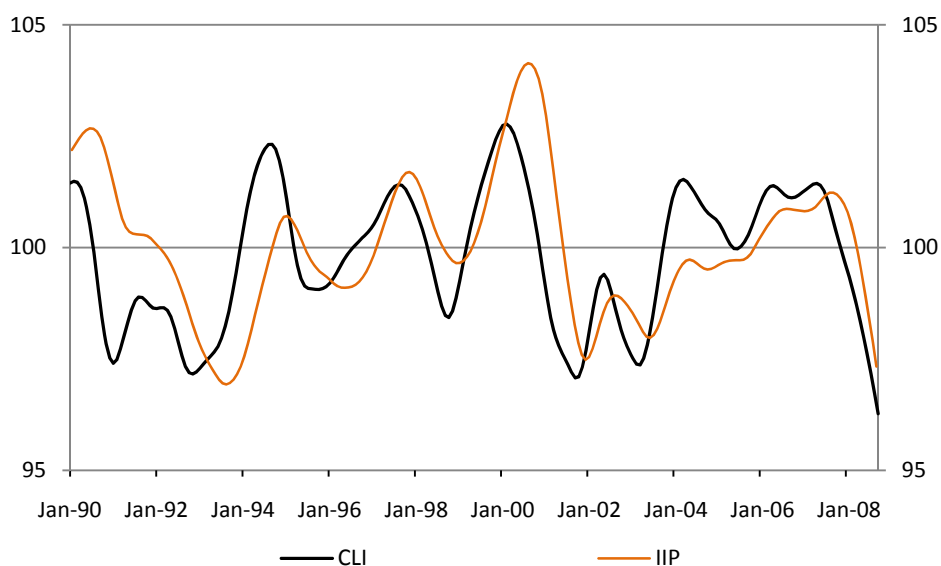
PRESENTATION

CLIs can be presented in several forms, reflecting, in the main, user needs. The following forms are all produced in the OECD CLI system:

The amplitude adjusted CLI vs. the de-trended reference series

This is the most straightforward way to present the CLI. The CLI is the average of de-trended and smoothed component series, and similarly the reference series is also de-trended and smoothed. The amplitude adjusted CLI rescales this 'averaged' CLI to match the amplitudes of the de-trended reference series. The turning point chronology, referred to above, is also made with respect to this form. This form allows for "output-gap" type interpretations.

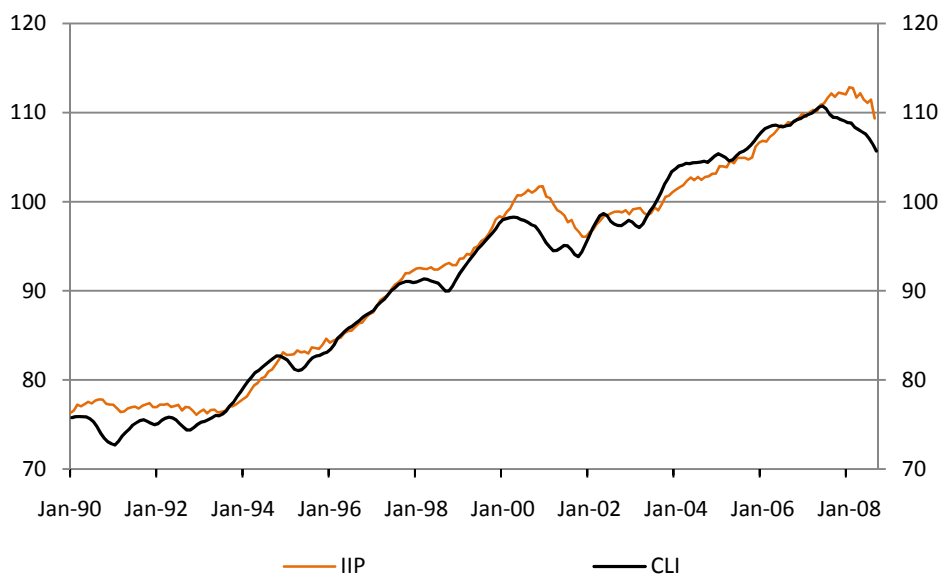
Growth Cycle



The trend restored CLI vs. the original reference series

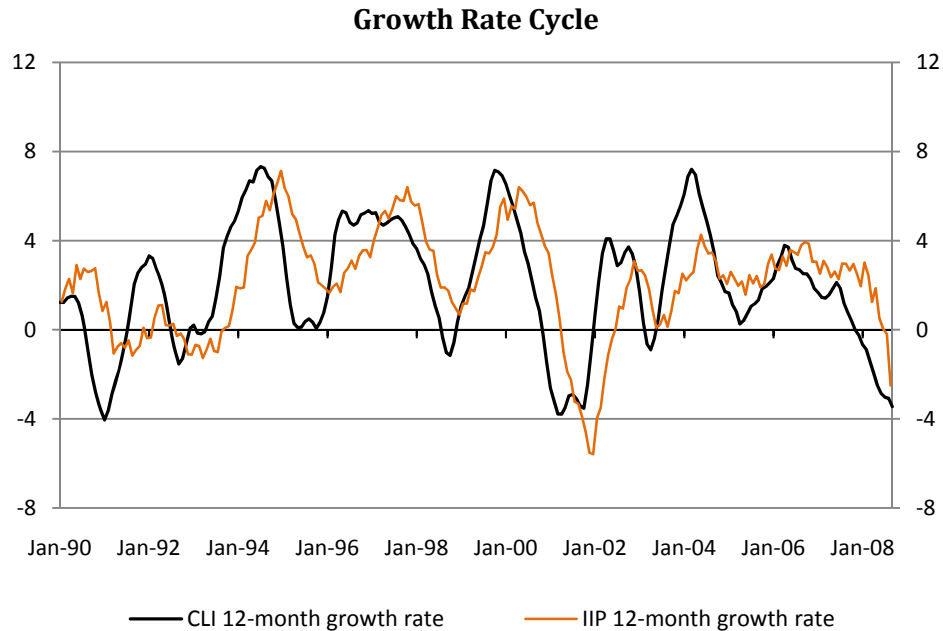
The trend restored CLI follows from the amplitude adjusted CLI. It reflects the product of the trend of the reference series (in index form or natural units) and the amplitude adjusted CLI. This transformation of the CLI facilitates analyses of trend cycles or classic business cycles. The trend restoration alters the position of peaks and troughs: peaks occur later and troughs occur earlier in the trend restored series than in the amplitude adjusted series. Please note that the OECD turning point chronology will not align optimally with the turning points in the trend restored CLI or with the turning points in the original reference series. (For more details on these two ways of presenting the CLI see <http://www.oecd.org/dataoecd/17/38/39430336.pdf>).

Business Cycle

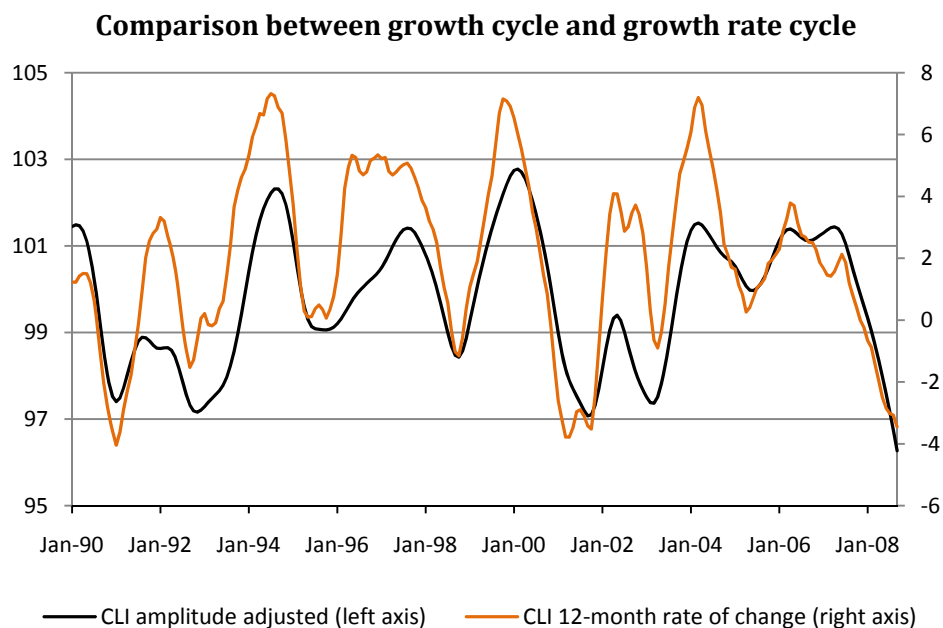


The 12-month rate of change of the CLI vs. similar reference series

The 12-month rate of change series are calculated from the trend restored CLI. They are comparable with the growth rate series of industrial production or GDP growth rates. Some analysts prefer this depiction since the reference series is most often published in this format by national statistics offices.



A completely coherent cyclical analysis can be built on this form of the CLI but care is needed in interpretation to avoid mixing results and messages based on different forms of the CLI. Although the cyclical patterns in the 12-month rate of change series are similar to those observed in the amplitude adjusted series, peaks and troughs in the two forms have different economic meaning and therefore should be interpreted differently (as can be seen in the graph below).



Peaks in the amplitude adjusted series denote that the output-gap has started to decrease, whereas peaks in the 12-month rate of change indicate decreases in output growth. A peak in the 12-month rate of change usually marks an inflection point in the amplitude adjusted series. It should be noted however, that the lead time of the rate of change series is not stable, as shown in the graph above for example. Indeed deductions based on the relationship between the two forms can often be misleading. The 12-month rate of change series may for example signal false alarms: in turning points in the amplitude adjusted CLI series.

ANNEX A – CYCLES EXTRACTION (de-trending and smoothing)

The OECD CLI system uses the "deviation-from-trend" approach. This means that in the construction phase of the CLIs co-movements and similarities in patterns between the reference series and individual CLI components are evaluated between smoothed and de-trended versions of these series. This makes the cycle extraction (the equivalent of de-trending and smoothing) a crucial step in the CLI selection and production process. Therefore we analyse competing cycle extraction methods in considerable detail.

We can approach the cycle extraction exercise slightly differently than the distinct steps of trend removal and smoothing. Instead of observing the series in the time domain, we can treat the series as a complex sinusoid, built from simple sine waves of different wave length. The trend part of the series is comprised by the low frequency (high wave length) sinusoids, whereas the noise is formed by a set of high frequency sinusoids See Pollock [2006] for a thorough introduction to the related mathematical concepts of this decomposition.

Once we have the translation of our series from the time domain to the frequency domain, we can single out the cycles we are interested in, and eliminate the components whose wave length is too long (trend) or too short (noise). Much depends on the optimal cycle length, an issue on which there is considerable debate: What is a business cycle? How long should a cycle be? Or, more closely related to the de-trending exercise, what is the cycle length that we consider too short or too long to treat meaningfully as a business cycle?

The early papers in cyclical analysis characterize movements between 1.5 and 8 years as the cycle length of interest. More recent papers tend however to argue that modern economic cycles last longer, and cyclical fluctuations are smaller. (For example see Agresti and Mojon [2001] who endorse 10 years as the upper boundary for the business cycles in Europe.) The de-trending and smoothing methods chosen therefore are necessarily aligned with prior expectations on business cycles.

The following sections provide more detailed information on the 3 methods considered by the OECD in its recent review of the CLI system:

1. [**Phase Average Trend \(PAT\) Method**](#)
2. [**Hodrick-Prescott \(HP\) Filter**](#)
3. [**Christiano-Fidgerald \(CF\) Filter**](#)

Phase Average Trend (PAT) Method

This was the method used in the OECD CLI system since its conception till November 2008. It is the modified version of the PAT method developed by the United States NBER and which is used in combination with the Bry-Boschan turning point detection algorithm. The resulting medium-term cycle is smoothed by the MCD (month for cyclical dominance) method to yield the final smooth cycle.

The PAT method consists of the following set of operations:

- first estimation and extrapolation of long-term trend (75 month moving average);
- calculation of deviations from moving average trend;
- correction for extreme values; identification of tentative turning points and determination of cyclical phases, i.e. expansions and contractions (Bry-Boschan routine);
- second estimation of the long-term trend; calculation of averages for each phase, smoothing the sequence of phase averages over three adjacent phases. Finally these smoothed values are positioned in the centre of their corresponding phases and linearly interpolated.
- extrapolation of the long-term trend at the series ends to recover periods lost because of the centred moving averaging;
- calculation of deviations from PAT trend;

The implementation of PAT works in two modes: automated and manual (supervised) mode. The automated mode uses the turning points from the Bry-Boschan algorithm, the supervised mode accepts turning points entered by the user, and ignores Bry-Boschan values. As most of the parameters of the PAT procedure are fixed, the manual turning point setting provides a mechanism to fine-tune the system, and modify implausible cycle results. The manual turning point setting gives the analyst a very strong and precise tool to intervene in the de-trending process. At the same time this targeted intervention possibility is one of the most criticized features of PAT. The rules or conventions that govern the intervention of the analyst are not easy to document, different analysts may come up with different turning point choices, and, as a consequence, the PAT with manual turning point specification suffers from a perception that it is a non-transparent, ad-hoc system.

The PAT method in automatic mode has a tendency to select cycles between 15 and 75 month, as a direct consequence of parameters fixed in the PAT software. These cycle lengths are somewhat shorter than the cycle lengths in which the OECD is interested: 18 to 96 month. Therefore a manual intervention is needed to remove minor cycles, and a rerun of the process in supervised mode is needed to recalculate the trend. This sets in motion an iterative process. The OECD runs the trend calculation with input turning-points and then checks whether the turning points in the estimated cycle (i.e. the de-trended series) correspond to those input turning-points. If they do not match, the OECD reruns the trend calculation with the turning points observed in the cycle. Convergence is usually achieved after one or two iterations.

The smoothing coupled with the PAT method is the so called MCD (month for cyclical dominance) moving average. This procedure ensures approximately equal smoothness between series and also ensures that the month-to-month changes in each series are more likely the result of cyclical rather than irregular movements. The time span of the MCD moving average value is defined as the shortest span for which the I/C ratio is less than unity, and where I and C are average absolute month-to-month changes of the irregular and trend-cycle component of the series, respectively. The maximum value of MCD is capped at 6 months.

Hodrick-Prescott (HP) Filter

The Hodrick-Prescott filter is one of the best known and most widely used de-trending methods. The filter was first described in Hodrick and Prescott (1997; following a working paper published in 1981). In its original form the trend estimate is the result of an optimization problem:

$$y_t = \tau_t + c_t$$
$$\min_{\tau_t} \sum_t (y_t - \tau_t)^2 + \lambda \sum_t (\tau_{t+1} - 2\tau_t + \tau_{t-1})^2$$

The initial y_t series is decomposed into τ_t - the trend component and c_t - the cyclical component, with the objective being to minimize the distance between the trend and the original series and, at the same time, to minimize the curvature of the trend series. The trade-off between the two goals is governed by the λ parameter.

The optimization problem has a solution that can be represented by a linear transformation which is independent from y_t . (see Maravall and del Rio [2001]). This makes the filter very fast.

What was impossible with the PAT method is possible with the HP filter. Namely, it is possible to transform the filter into the frequency domain and interpret/quantify its effects on various cycles that make up the time series.

The λ parameter determines the shape of the frequency response function of the HP filter and the cut-off frequency. The frequency response function shows how the filter affects certain frequencies, it shows which frequencies are retained and which are let through. The cut-off frequency is defined as the frequency where 50% is let through and 50% is retained from the original power of the cycle. Thus one can align the λ parameter with our goal to filter out economic cycles in a certain frequency range with the help of the transformation into the frequency domain.

Before the frequency domain interpretation emerged there were only rules of thumb to set the λ parameter. Rule of thumb values later proved to be in line with values that had been determined by frequency selection criteria, i.e. separating the "trend" cycles with a wavelength larger than 8 years. See for example Maravall and del Rio [2001] to learn more on how the λ parameter translates to the frequency domain.

Properties of the HP filter:

- The cut-off region is not steep; meaning that leakage from cycles from just outside the target region can be significant. In engineering applications filter leakage is a sign of a poor filter. However, in business cycle analysis there are arguments to support at least a small degree of desirable leakage. Since the frequency band of 1.5 to 8 years has been selected based on expert judgement several decades ago, the boundaries 1.5 and 8 years should not be regarded as carved in stone. The filter leakage for example lets strong 9 year cycles appear in the filtered series.
- It is asymmetric. With the exception of the central values the double HP filtered series are phase shifted compared to the underlying ideal cycle. Phase shifts vanish for a given observation as newer observations arrive.

We apply the HP filter twice to achieve a smoothed de-trended cycle. First we remove the long term trend by setting λ to a high value, and we preserve the business cycle frequencies and the high frequency components. Second, we apply the HP filter with a smaller λ , meaning that the cut-off frequencies are much higher, and so, preserve the trend part of the filter results. The first step de-trends the second step smoothes.

Christiano-Fitzgerald (CF) filter

The Christiano-Fitzgerald random walk filter is a band pass filter that was built on the same principles as the Baxter and King (BK) filter. These filters formulate the de-trending and smoothing problem in the frequency domain. With continuous and/or infinitely long time series the frequency filtering would be an exact procedure. However the discrete nature of data do not allow for such perfection. Both the BK and CF filters approximate the ideal infinite band pass filter. The Baxter and King version is a symmetric approximation, with no phase shifts in the resulting filtered series. But symmetry and phase correctness comes at the expense of series trimming. Depending on the trim factor a certain number of values at the end of the series cannot be calculated. There is a trade-off between the trimming factor and the precision with which the optimal filter can be approximated. On the other hand, the Christiano-Fitzgerald random walk filter uses the whole time series for the calculation of each filtered data point. The advantage of the CF filter is that it is designed to work well on a larger class of time series than the BK filter, converges in the long run to the optimal filter, and in real time applications outperforms the BK filter. For details see Christiano-Fitzgerald [1999]. For these reasons we included only the Christiano-Fitzgerald filter in our study that compares different cycle detection methods.

The CF filter is a steep, asymmetric filter that converges in the long run to the optimal filter. It can be calculated as follows:

$$c_t = B_0 y_t + B_1 y_{t+1} + \dots + B_{T-1-t} y_{T-1} + \tilde{B}_{T-t} y_T + B_1 y_{t-1} + \dots + B_{t-2} y_2 + \tilde{B}_{t-1} y_1, \text{ where}$$

$$B_j = \frac{\sin(jb) - \sin(ja)}{\pi j}, j \geq 1, \text{ and } B_0 = \frac{b-a}{\pi}, a = \frac{2\pi}{p_u}, b = \frac{2\pi}{p_l}$$

$$\tilde{B}_k = -\frac{1}{2} B_0 - \sum_{j=1}^{k-1} B_j$$

The parameters p_u and p_l are the cut-off cycle length in month. Cycles longer than p_l and shorter than p_u are preserved in the cyclical term c_t .

ANNEX B – TURNING POINTS DETECTION

The Bry-Boschan algorithm (see Bry and Boschan [1971]) identifies local peaks and troughs in a smoothed version of the input series. Following this it checks minimum phase and minimum cycle length criteria and eliminates turning points that set outside of these limits.. The Bry-Boschan routine specifies a minimum duration of five months for a phase and fifteen months for a cycle. In various iterations increasingly less smoothing is applied to the input series, and turning points are slightly corrected. At the end of the process the turning points are sought in the original series within the five months on both sides of the turning points found at the preceding stage.

The main problem with the Bry-Boschan routine running in combination with the PAT method is that it tends to select too many turning points, thereby giving a long-term trend which is too variable. Relatively minor fluctuations may be selected by the routine and given the same weight as more important cycles. The number of selected turning points is just partly related to the settings of the Bry-Boschan routine. They are in fact mostly inherited from the PAT procedure which tends to filter out cycles that are shorter, and the MCD procedure which does not smooth strongly enough a number of series.

The double HP filter and the CF filter yield much smoother cycles, therefore the Bry-Boschan routine can be simplified. The smooth cycles do not require several iterations; it is sufficient to locate the peaks and troughs of the series sequentially, whilst respecting phase and cycle-length constraints.

There are several other turning point dating alternatives. Bruno and Otranto [2004] provide an exhaustive classification of turning point dating methods coupled with cycle identification methods. Parametric methods operate in fully model based settings, usually in hidden variable Markov Switching type models, deriving from Hamilton [1989]. The adaptation of these turning point dating methods to the OECD CLIs is not however straightforward. The non-parametric methods from the Bry-Boschan family harmonize best with other elements of the OECD CLI system.

BIBLIOGRAPHY

- OECD (1987)** "OECD Leading Indicators and Business Cycles in Member Countries, Sources and Methods 1960-1985", N0-39.
- OECD (1997)** "Cyclical Indicators and Business Tendency surveys", OCDE/GD(97)58, *General Distribution*.
- A. Agresti, B. Mojon (2001)**, "Some Stylized Facts on the Euro Area Business Cycle", *ECB Working Paper series, WP No. 95*
- M. Baxter, R. G. King (1999)**, "Measuring Business Cycles: Approximate Band-Pass filters for Economic Time Series", *The Review of Economics and Statistics, Vol. 81, No. 4*, pp. 575-593
- C. Boschan, W.W. Ebanks (1978)**, "The Phase Average Trend: A New Way of Measuring Economic Growth", *Proceedings of the Business and Economic Statistics Section. American Statistical Association, Washington, D.C.*
- G. Bruno, E. Otranto (2004)**, "[Dating the Italian Business Cycle: A Comparison of Procedures](#)", *ISAE Working Papers* 41, ISAE (Rome, ITALY).
- G. Bry, C. Boschan. (1971)**, "Cyclical Analysis of Time Series: Selected Procedures and Computer Programs," *Technical Paper 20, NBER*
- L. J. Christiano, T. J. Fitzgerald (1999)**, "The Band Pass Filter" *NBER Working Paper No. W7257*.
- J. D. Hamilton (1989)**, "A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle", *Econometrica, Vol. 57, No. 2.*, pp. 357-384.
- D. Harding, A. Pagan (2003)**, "A Comparison of Two Business Cycle Dating Methods", *Journal of Economic Dynamics and Control*, Elsevier, vol. 27(9), pp. 1681-1690, July
- R.J. Hodrick, E.C. Prescott (1997)**, "Postwar U.S. Business Cycles: an Empirical Investigation", *Journal of Money Credit and Banking* 29 (1), pp. 1-16.
- A. Maravall (2006)**, "An Application of the TRAMO-SEATS Automatic Procedure; Direct versus Indirect Adjustment", *Computational Statistics & Data Analysis* No. 50, pp. 2167 - 2190.
- A. Maravall, A. del Rio (2001)**, "Time Aggregation and the Hodrick-Prescott Filter", *Banco de Espana Working Paper Series* 2001(08).
- R. Nilsson (1987)** "OECD Leading Indicators", *OECD Economic Studies*, No. 9.
- D.S.G. Pollock (2006)**, "Statistical Fourier Analysis: Clarifications and Interpretations", available online at the Queen Mary University of London: <http://alpha.qmul.ac.uk/~ugte133/papers/statfour.pdf>
- OECD** Statistics Note, October 2007, "Changes to the OECD's Composite Leading Indicator", available at: <http://www.oecd.org/dataoecd/17/38/39430336.pdf>

Further documents related to the OECD CLI system can be found on the OECD Business Cycle Analysis webpage: <http://stats.oecd.org/mei/default.asp?rev=2>